

**REMARKS**

Claims 29-60 are all the claims presently pending in this application. Claims 29, 31-33, 35, and 46-47 have been amended to more particularly define the claimed invention.

No new matter has been added.

It is noted that the claim amendments are made only for more particularly pointing out the invention, and not for distinguishing the invention over the prior art, narrowing the claims or for any statutory requirements of patentability. Further, Applicant specifically states that no amendment to any claim herein should be construed as a disclaimer of any interest in or right to an equivalent of any element or feature of the amended claim.

With respect to the prior art rejections, claims 29-38 and 46-50 stand rejected under 35 U.S.C. § 103(a) as being allegedly unpatentable over Birks et al. (U.S. Patent No. 6,334,019) in view of JP 2002-236234 ('234).

These rejections are respectfully traversed in view of the following discussion.

**I. THE CLAIMED INVENTION**

An exemplary aspect of the claimed invention (e.g., as recited in claim 29) is directed to an optical fiber, which may include a core including a quartz-based material, a cladding including the quartz-based material, and a plurality of air holes around the core along an axial direction of the optical fiber, wherein said air holes in proximity of a connecting end of said optical fiber are filled with a light transparent material made of a UV-curable resin that has a refractive index after curing lower than that of the quartz-based material, the refractive index after curing is determined such that a mode field diameter of the optical fiber is equal to that of a single mode optical fiber to be connected to the connecting end of the optical fiber (Application at page 12, lines 14-18 and 26-27 and page 41, lines 7-11).

Conventional optical fibers include photonic crystal fibers. Conventional methods of optical fiber connection include heating an end of a photonic crystal fiber that is to be connected and mounting the end to a ferrule. However, the above connection method can be applied only to a photonic crystal fiber whose core is formed of a material with a higher refractive index than that of its cladding. Further, the above connection method cannot be applied to a fiber structure whose core and cladding have the same refractive index. It also cannot be applied to fiber structure in which a photonic crystal structure with cylindrical air holes allows light to be confined in the core by equivalently providing a refractive index difference between the core and cladding. Heating the photonic crystal fiber end that is to be connected causes fusion bonding of the wall of the cylindrical air holes such that the air holes vanish and a core does not develop. The lack of a core leads to an increase in connection loss (Application at page 3, line 23 to page 4, line 8).

On the other hand, the aforementioned exemplary aspect of the claimed invention includes an optical fiber in which **air holes in proximity of a connecting end of said optical fiber are filled with a light transparent material made of a UV-curable resin that has a refractive index after curing lower than that of the quartz-based material, the refractive index after curing is determined such that a mode field diameter of the optical fiber is equal to that of a single mode optical fiber to be connected to the connecting end of the optical fiber** (Application at page 12, lines 14-18 and 26-27 and page 41, lines 7-11). This feature may prevent signal strength degradation and transmission loss (Application at page 13, lines 15-16).

## II. THE PRIOR ART REJECTIONS

The Examiner alleges that the combination of Birks and the '234 reference teaches or suggests the invention of claims 29-38 and 46-50. **However**, Applicant respectfully submits that Birks and the '234 reference would not have been combined. **Further**, even assuming

(arguendo) Birks and the '234 reference were combined, the resultant combination **fails to teach or suggest every element of the invention of claims 29-38 and 46-50.**

#### A. The Rejection of Claims 29-38

The invention of claim 29 includes an optical fiber which includes a core and a cladding, both including a quartz-based material, air-holes filled with a UV-curable resin, and a refractive index determined such that, after curing of the UV-curable resin, a mode field diameter of the optical fiber is equal to that of a single mode optical fiber to be connected to the optical fiber.

The Birks reference merely suggests a **single mode photonic crystal fiber**. There is no teaching or suggestion about a connection between an optical fiber with air holes and a single mode fiber including **mode field diameters that are equal**. Therefore, Birks does **not** teach or suggest the invention of claim 29.

The '234 reference discloses an optical transmission line including a connected part of optical fibers and a connecting method. The Examiner alleges that the '234 reference discloses an index matching material (oil) which has a lower index of refraction than its quartz core. **However**, even assuming (arguendo) the '234 reference is combined with Birks, the resultant combination **fails to teach or suggest the invention of claim 29.**

Paragraphs 19 and 20 of the '234 reference begin to describe the first of two preferred embodiments disclosed in the '234 reference. This first preferred embodiment discloses an optical fiber 1 without a hollow region and consists of a core region 3 and a cladding region 4, where a refractive index of the core region 3 is greater than that of the cladding region 4. The optical fiber 1 is connected to an optical fiber 2, which consists of a core region having a hollow structure (hollow core region) 5 and a silica glass cladding region 6, where a refractive index of the hollow core region 5 is smaller than that of the cladding region 6. In paragraph 24, a matching oil M to be injected to the

hollow core region 5 is a substance having a refractive index which is greater than that of a medium forming the cladding region 6. In paragraph 30, the ultraviolet-curable resin S has a refractive index greater than that of the material forming the cladding region 6. The '234 reference is silent to the refractive index after curing of the ultraviolet curable resin S.

Paragraphs 34 to 35 begin to disclose the second preferred embodiment of the '234 reference. In this embodiment, the optical fiber 1 is connected to an optical fiber 12, which is formed of silica glass and consists of a core region 13 and a cladding region 14. The core region 13 is doped with dopant and the refractive index of the core region 13 is greater than that of the cladding region 14. A plurality of hollow regions 15 extending along the optical fiber 12 are formed around the core region 13. In paragraph 36, it is described that a matching oil M to be injected to the hollow regions 15 has a refractive index approximately equal to the refractive index of a medium that forms the cladding region 14. Paragraph 37 discloses that the ultraviolet-curable resin S may be used for connecting the optical fibers 1 and 12, and the refractive index of the matching oil M may be greater than that of the hollow region 15.

**However, in the '234 reference, it is neither disclosed nor suggested that "said air holes in proximity of a connecting end of said optical fiber are filled with a light transparent material made of a UV-curable resin that has a refractive index after curing lower than that of the quartz-based material, the refractive index after curing is determined such that a mode field diameter of the optical fiber is equal to that of a single mode optical fiber to be connected to the connected end of the optical fiber", as recited in claim 29 of the invention (Application at page 12, lines 14-18 and 26-27 and page 41, lines 7-11). The '234 reference is clearly silent to the problem of reduction in volume of the UV-curable resin after curing.**

The invention of claim 29 **clearly** includes an optical fiber in which the refractive index of the air holes filled with the UV-curable resin after curing is adjusted to be lower than that of the

cladding comprising the quartz-based material such that a mode field diameter of the optical fiber is equal to that of the optical fiber to be connected.

**Therefore**, even if the '234 reference is combined with Birks, the invention of claim 29 would not have been obvious for a skilled person in the art.

As described above, the invention of claim 29 would **not** have been obvious for those ordinarily skilled in the art in view of the cited references. Since claims 30 to 32 **are dependent on** claim 29 and claims 33-34 include **the same optical fiber** as does claim 29, they are also patentable over the cited references.

Further, claim 32 states that the optimum value of the refractive index of the UV-curable resin after curing is 1.42. According to this structure, an effect of confining the light into the core can be optimized, so that connecting loss with the single mode optical fiber can be reduced to the minimum.

If the refractive index of the UV-curable resin after curing is slightly higher than that of the cladding, then the air holes formed around the core constitute pseudo-cores, so that the mode field diameter of the holey fiber will be greater than that of the single mode fiber. If the refractive index of the UV-curable resin after curing is equal to that of the cladding, the bending property of the holey fiber will be lost. Further, if the refractive index of the UV-curable resin is greater than that of the air holes (around 1.0) but much smaller than 1.42, the confinement effect is increased and the mode field diameter of the holey fiber will be smaller than that of the single mode fiber.

The invention of claim 35 includes that the air holes are sealed by a sealing portion made of a melt of a glass powder with a particle diameter of 1  $\mu\text{m}$  or less. The Examiner alleges the combination of Birks and '234 teaches or suggests the elements of claims 35-38.

**However**, the Examiner **completely fails** to offer any explanation or rationale related to the rejection of claims 35-38. The Examiner states simply that the combination of Birks and the '234 reference "discloses the structure as claimed and described above" (Office Action at page 4,

paragraph 5). Applicant respectfully submits that the explanation provided by the Examiner is clearly not adequate.

**Therefore**, Applicant respectfully **requests** the Examiner to provide **proof** that the cited references in fact teach or suggest the invention of claims 35-38.

**Further**, even assuming (*arguendo*) Birks was combined with the '234 reference, the resultant combination **neither** teaches nor suggests that the air holes are **sealed** by a melt of a glass powder with a particle diameter of 1  $\mu$ m or less. As a result of this feature, the outer diameter of the cladding may be kept and the sealing effect of the sealing portion may be improved. **Therefore**, the invention of claim 35 should have an unexpected result in view of the cited references.

As described above, the invention of claim 35 would **not** have been obvious for those skilled in the art in view of the cited references. **Therefore**, since claims 36-38 are dependent on claim 35, they are also **patentable** over the cited references.

#### B. The Rejection of Claims 46-50

The invention of claim 46 may include a quartz-based fine particle having a **diameter of 100 nm or less**. The cited references, alone or in combination, **neither teach nor suggest** the structure of the holey fiber and the use of the quartz-based fine particle with a **diameter of 100 nm or less**.

This feature may enable a volume ratio of the quartz-based fine particle in the sealing part to be increased, so that a mix ratio of the quartz-based fine particle in an optical adhesive can be improved. Therefore, generation of air bubbles at the sealing portion may be effectively reduced.

The Examiner alleges that doping the cladding or portions of the fiber is well known in the art. However, even if it has been well known in the art to vary a refractive index by doping an impurity such as Ge or F to a core or a cladding, it has **not** been well known in the art to use a quartz-based fine particle with a predetermined diameter (**a diameter of 100 nm or less**) in a sealing portion

such as a resin for sealing the air holes.

**Therefore**, the invention of claim 46 and all of the claims dependent on claim 46 would not have been obvious for those skilled in the art in view of the cited references, even if the cited references were combined.

### **III. FORMAL MATTERS AND CONCLUSION**

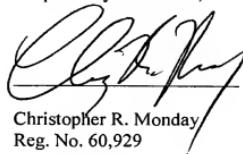
In view of the foregoing, Applicant submits that claims 29-60, all of the claims presently pending in the application, are patentably distinct over the prior art of record and are in condition for allowance. The Examiner is respectfully requested to pass the above application to issue at the earliest possible time.

Should the Examiner find the application to be other than in condition for allowance, the Examiner is requested to contact the undersigned at the local telephone number listed below to discuss any other changes deemed necessary in a telephonic or personal interview.

The Commissioner is hereby authorized to charge any deficiency in fees or to credit any overpayment in fees to Attorney's Deposit Account No. 50-0481.

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Respectfully Submitted,



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